Memorial Sloan Kettering Cancer Center

Are You Ready When Patients Undergoing Radiotherapy Have Such Implanted Devices?

Maria Chan, PhD, DABR, DABMP, FAAPM

AAPM Spring Clinical Meeting

March 26-29, 2022

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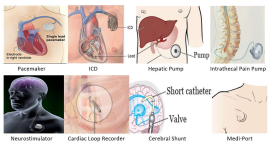
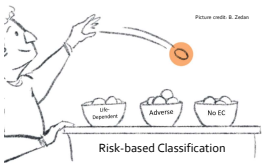
This talk provides you with the essential information on managing commonly seen implanted devices for patients under radiotherapy



Identifying Implanted Devices (ID)



Categorizing & Managing ID

No relevant conflict of interest

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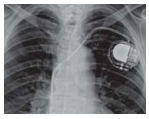
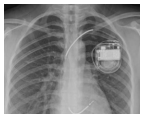
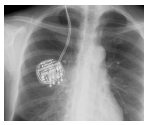
Commonly seen implanted devices in Radiation Oncology

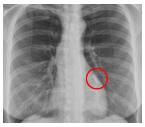

Pacemaker


ICD


Hepatic Pump


Intrathecal Pump


Neurostimulator


Cardiac Loop Recorder


Cerebral Stunt


Medi-Port

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Picture credits: Wikipedia.org, Korean J of Ped, Wikidoc, Dove Press, Radiopaedia, StatPerals Publishing, en.Wikipedia.org

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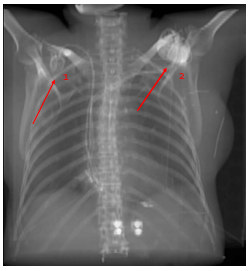

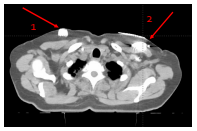

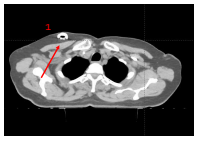

(1) Right Vascular Port, (2) Pacemaker

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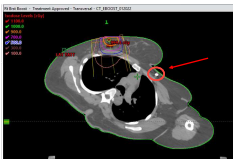
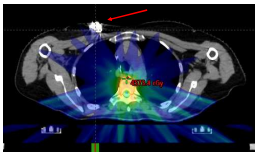
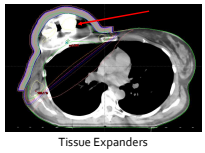

Cardiac Loop Recorder

Devices shown in Eclipse treatment planning


Central venous access devices (CVADs)


Tissue Expanders

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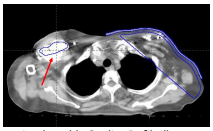
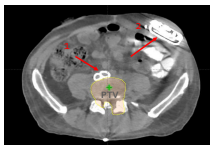
Intrathecal Pump in DRR


Implantable Cardiac Defibrillator


(1) Peripheral Artery Stent, (2) Infusion Drug Pump

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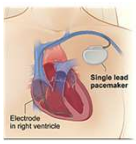
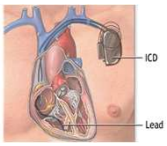
Patients with Cardiac Implantable Electronic Devices (CIEDs)

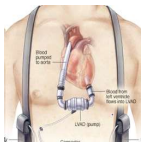


Cardiac Pacemaker, CRT-P



Implantable Cardiac Defibrillator, CRT-D

Cardiac Loop Recorder



Left Ventricle Assist Device (LVAD)

Under the same labeling of cardiac rhythm devices - all have CMOS circuitry

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Picture credit: NHLBI, Mayo Clinic

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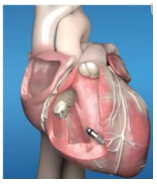
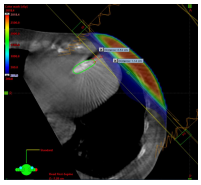
Leadless Pacemaker (MR Compatible)

Relative size to a penny



Implanted in the right ventricle



CBCT blended in TPS w/ 2Gy color-wash

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Wang D, Chan MF, Zambri J, Lichtenwalner P, et al., *Advances in Radiation Oncology*, 2021, DOI:10.1016/j.adro.2021.100726

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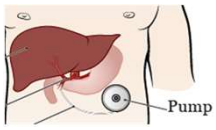
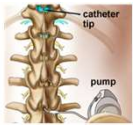
Patients with Non-CIEDs Implanted Devices

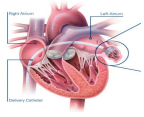
Neurostimulator



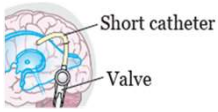
Programmable Hepatic Pump



Intrathecal Pump



Watchman Device



Cerebral Shunt

Medi-port

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Categorizing and Managing of Implanted Devices

Risk-based Classification

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Factors Impacting Implanted Devices

Device Type

How far to RT

Energy/ Modality

Beam Orientation

Dose Rate

Total Dose

Shielding

Patient Anatomy/ Physiology

Frequency of RT

Concurrent Therapy

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Table 1 Commonly seen implanted devices and their uses, categories, dose limits, historic malfunction

Implanted device	Clinical use	Susceptible component	Category	Dose limit	Historical malfunctions reported	References
Pacemaker	Control heartbeat	CMOS RAM Battery	Life-dependent	2-5 Gy	Transient damage Permanent damage EC damage Parameter reset Signal interference Battery depletion	8,9,18,19, 33,38,46
ICD	Sends electrical signals to the heart	CMOS RAM Battery	Life-dependent	0.5-2 Gy	Transient damage Permanent damage Pacing pulse change Pacing frequency change Sensing threshold change Lead impedance change Loss of telemetry capability Loss of signal/data Battery depletion	8,14,18,19, 33,38,39
Programmable hepatic pump	Gives continual chemo-therapy to the liver	EC, Battery	Adverse	10 Gy*	NA	20
Intrathecal pain pump	Gives continual pain medication to spine	EC, Battery	Adverse	28.5 Gy	EC damage Battery depletion Pump alarm	4,13
Neurostimulator	Sends electrical signals to the brain and spine	Implantable pulse generator	Adverse	5 Gy	NA	10,11,12
Loop recorder	Monitors heart rhythm	CMOS Battery	Adverse	5 Gy†	NA	5,39
Mediport	Vein access point for chemotherapy, IV, etc	NA	Without circuits	NA	NA	22
Cerebral shunt	Drains excess CSF from brain	NA	Without circuits	NA	NA	21

Abbreviations: CMOS = complementary metal oxide semiconductors; CSF = cerebrospinal fluid; EC = electronic circuit; IV = intravenous; NA = not applicable.
* Private communication from the manufacturer, Medtronic, Minneapolis, MN, October 23, 2019.
† A conversation needed with the cardiologist on the fidelity of the information retrievable after radiation.

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Chan MF, Young C, Gelblum D, Shi C, et al, *Advances in Radiation Oncology*, 2021, DOI:10.1016/j.adro.2021.100732

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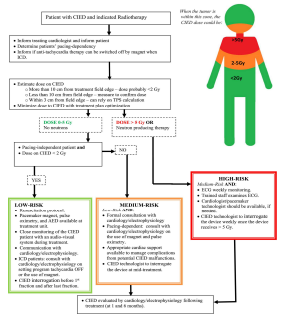

AAPM TG-203 on CEIDs

Management of radiotherapy patients with implanted cardiac pacemakers and defibrillators: A Report of the AAPM TG-203

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Mifton M, Mihailidis D, Kry SF, Reft C, et al., *Medical Physics*, 46(12): e757-e788, 2019, DOI:10.1002/mp.13838

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Sample of Checklist on CIEDs in Radiation Oncology Dept.

PACEMAKER/DEFIBRILLATOR RISK ASSESSMENT

To be filled by Physics

Treatment courses: ☐ #FRACT

Distances:

- ☐ Distance between the device and field edge*: < 2 cm
- ☐ Distance between the device and field edge: 2 - 10 cm
- ☐ Distance between the device and field edge: ≥ 10 cm

*50% proton line can be used as a substitute for a displayed field edge in VMAT/IMRT

Energies:

- ☐ >10 MV
- *Others:*
- ☐ Non-coplanar photon beam used (except for intracranial SRS)

To be filled by MD

Device Dependency

This patient has an implanted pacemaker or defibrillator and is:

☐ **Device dependent** ☒ **Not device dependent**

Risk Category*

☒ LOW RISK

- Dependence: Patient is NOT device dependent **AND**
- Distance: Device is ≥ 10 cm from closest field edge

☐ MEDIUM RISK (please indicate OSL on eNc)

- Dependence: Patient is device (pacing) dependent **OR**
- Distance: Device is between 3 - 10 cm from closest field edge **OR**
- Others: Non-coplanar photon (except for intracranial SRS)

☐ HIGH RISK (please indicate OSL on eNc)

- Distance: Less than 3 cm from field edge **OR**
- Energy: >10 MV photon

Upon completion, click "approve".

*"For any other circumstances, please refer to **Rad Onc Policy & Procedure #5007** "Patients with Implanted Cardiac Pacemaker or Implanted Cardioverter-Defibrillator" for a case-by-case decision.

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Credit: MSKCC Rad Onc Policy on Pacemakers & ICDs adopted from the AAPM TG-203

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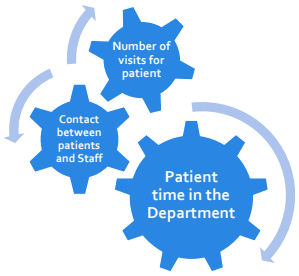
Management of RT patients with CIEDs in a pandemic

Risk-based CIEDs management can **minimize** -



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Chan MF, Young C, Gelblum D, Shi C, et al, *Advances in Radiation Oncology*, 2021, DOI:10.1016/j.adro.2021.100732

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Patients undergoing Proton Therapy

Low Risk	• < 2 Gy • CIED-independent
Medium Risk	• Cardiology expert present • Monitor before/after RT
High Risk	• Monitor every fraction • Follow up 1,3,6 months

If the patient is pacing-depending, it is usually not recommended to treat them with proton therapy, especially in standalone centers with limited resources.

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Chan MF, Young C, Gelblum D, Shi C, et al, *Advances in Radiation Oncology*, 2021, DOI:10.1016/j.adro.2021.100732

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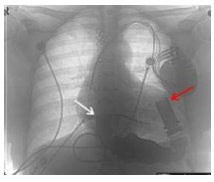
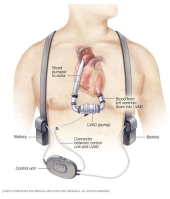
Left Ventricular Assist Device (LVAD) (≤10MV photons)





LVAD is a life-sustaining device.

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Picture credit: Learningradiology.com, Mayo Clinic

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Neurostimulators (5 Gy Limit*)

Deep Brain Stimulator (DBS)

Spinal Cord Stimulator (SCS)

**Dose tolerances depending on the device/model*

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Picture credit: St. Jude Medical

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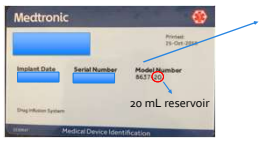
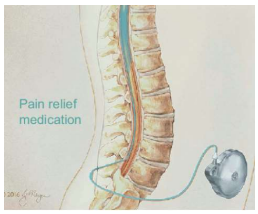
Intrathecal Pump (28.5 Gy Limit*)



Battery life 4-7 years



Intrathecal drug infusion system

*Dose tolerances depending on the device/model

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Picture credit: Dove Medical Press

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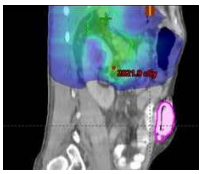
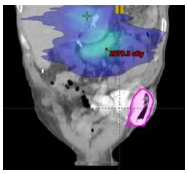
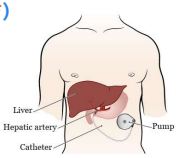
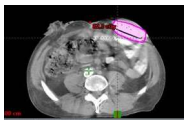
Programmable Hepatic Pump (10 Gy Limit*)





10 Gy isodose color-wash display in Eclipse TPS





*Dose tolerances depending on the device/model

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Picture credit: MSKCC.org

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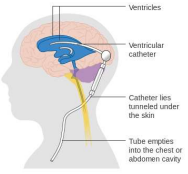
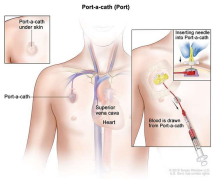
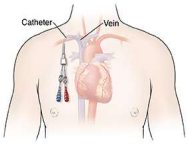
No Electronic Circuitry (No Dose Limit)



Brain Shunt



Medi-port



Central Venous Access Devices

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Picture credit: Wikipedia.org, Texas Winslow, StayWell

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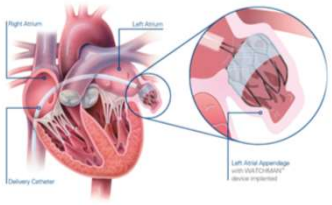
Watchman Device™ (No Dose Limit)



Left atrial appendage closure (LAAC) therapy to prevent blood clots from forming and causing a stroke.

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Picture credit: Archigen

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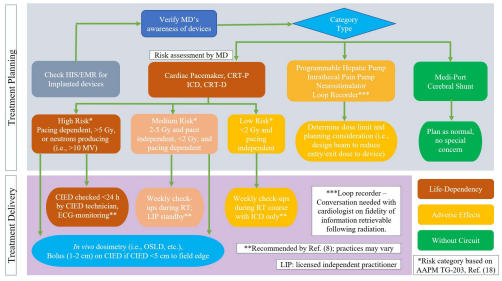
A sample workflow to handle implanted devices



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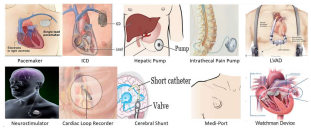
In summary, proper policies on implanted devices should be made so you will be ready when your patients have such devices

- Life-dependent
  - Pacemaker, Implantable Cardiac Defibrillator, CRT-P, CRT-D, LVAD
- Adverse
  - Loop recorders, Neurostimulators, Programmable Hepatic Pumps, Intrathecal Pumps
- No electronic
  - Brain Shunt, CVAD, Medi-port, Watchman Device, Tissue Expander, Peripheral Artery Stent



Questions?

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